

Description

A SYSTEM FOR RELIABLY REMOVING HEAT FROM A SEMICONDUCTOR JUNCTION

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Technical Field

This invention relates generally to semiconductor integrated circuits, and more specifically concerns a system for removing heat from such circuits generated by their operation.

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Background of the Invention

It is well known that integrated circuits (ICs) consume power, ranging from less than a few microwatts to more than several watts. This power is typically dissipated in the form of heat in the various semiconductor junctions present in the IC. If a semiconductor junction is heated beyond the limits established by the IC manufacturer, the IC may cease to function properly, may act erratically, and in some cases will be permanently damaged.

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The temperature of an IC junction can be calculated as follows, relative to the ambient or air temperature outside the electronic equipment containing the IC:

$$T_j = P_d * R_{ja} + T_a,$$

where T_j is the junction temperature in degrees centigrade (C), P_d is the power dissipated in the IC in watts (W), R_{ja} is the thermal resistance from the semiconductor junction to the ambient air outside the electronic equipment in degrees centigrade per watt (C/W), and T_a is the temperature of the ambient air outside the electronic equipment in degrees centigrade (C).

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R_{ja} can be expressed more specifically as the series combination of several individual thermal resistances, for instance:

$$R_{ja} = R_{jc} + R_{cs} + R_{se} + R_{ea}$$

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where R_{jc} is the thermal resistance from the semiconductor junction to the integrated circuit case/board, R_{cs} is the thermal resistance from the integrated circuit case to a heat sink, R_{se} is the thermal resistance from the heat sink to the

electronic equipment housing/chassis, and R_{ea} is the thermal resistance from the electronic equipment housing/chassis to the air surrounding the equipment.

It is desirable to maintain R_{ja} as small as possible so that T_j is maintained at a low (safe) thermal level. Although the thermal resistances may initially be small, there typically arises a problem with respect to heat dissipation when a printed circuit card is removed from the electronic equipment for repair or replacement. The removal results in the mechanical interface established during manufacture between the integrated circuit board and the heat sink, or the interface between the heat sink and the equipment chassis, being interrupted (broken).

When a new printed circuit board or a repaired board is replaced in the equipment, the newly established mechanical interface between the connected elements may result in a substantially higher total thermal resistance. In one solution, a force element, such as a threaded fastener, is used to provide the force of contact between the physical surfaces which have been previously broken. However, in many cases, the tool or tools which are necessary to tighten the threaded fastener cannot be used because of the particular equipment design and/or because of the location of the IC board in the equipment. In another attempted solution, a thermal grease or gasket is positioned between the thermal interfaces to reduce the thermal resistance of the system. However, the thermal grease or similar material is not easy to apply between the surfaces, particularly when the user attempts to reinstall a printed circuit assembly into a relatively small space in the electronic equipment.

Accordingly, it is desirable to have an IC thermal connection system which can be easily broken, such as when a printed circuit card is removed and then a new one installed while maintaining the original low thermal resistance, without the need for special tools or specialized material such as a thermal grease.

Summary of the Invention

Accordingly, the present invention is a system for removing heat from a semiconductor integrated circuit in electronic equipment, comprising: a heat sink member attached to a semiconductor integrated circuit which is part of an integrated circuit board assembly; a mounting member connected to or part of a chassis portion of the electronic equipment; and an attachment element positioned on the mounting member for receiving and releasing the heat sink, wherein when the heat sink is received by the attachment element, a low thermal resistance path is established from the integrated circuit to the mounting member, permitting heat to be conveniently removed from the integrated circuit.

Brief Description of the Drawings

Figure 1 is a perspective view showing a circuit board assembly using the IC thermal connection system of the present invention.

Figures 2A and 2B are a perspective view and a side elevational view, respectively, of a heat sink portion of the thermal connection system of Figure 1.

Figures 3A and 3B are perspective and side elevational views, respectively, showing a spring clip portion of the thermal connection system of Figure 1.

Figure 4 is a perspective view of the IC thermal connection system of the present invention as it is partially engaged in an electronic equipment chassis.

Figures 5A and 5B are side elevational and cross-sectional views, respectively of an engaged IC board assembly.

Figures 6A-6E show alternative spring clip configurations.

Best Mode for Carrying Out the Invention

Referring now to Figure 1, an example of an integrated circuit (IC) board assembly is shown generally at 10, which is also referred to as a printed circuit assembly, which is part of an electronic equipment unit 32 (Figure 4). The

printed circuit assembly 10 includes a circuit board 12 and a plurality of individual electronic elements or circuits mounted on the board, referred to, for example, at 14. The circuit board 12 will also typically include several multi-pin connectors 16. It should be understood, however, that the printed circuit board assembly 10 can vary widely in arrangement and configuration within the system of the present invention. The printed circuit board assembly shown in Figure 1 is just one example.

One element in the thermal connection system of the present invention is a heat sink 20, shown in Figure 1 but in more detail in Figures 2A and 2B. Heat sink 20 is made from a thermally conductive material, typically aluminum. In one example, heat sink 20 comprises a spindle-like member, with two identical outer discs (flanges) 21, 23, approximately 0.13 mm thick and 1.9 mm in diameter. The outer edges of the flanges 21, 23 are chamfered or rounded. Separating the two flanges 21, 23, is a central cylindrical portion 25 approximately 0.53 mm long and with a diameter of 1.3 mm. This is one example only; other heat sink configurations can be used. Heat sink 20, for instance, could be square, rectangular, oval or other configurations. The central portion will always have a smaller cross-section than the flange portions.

Heat sink 20 in the embodiment shown is permanently attached to a surface 26 of integrated circuit 14. The attachment may be made by mechanical means such as clips or threaded fasteners, or by double-sided thermally conductive tape, adhesive or other similar means.

A second portion of the thermal connection system of the present invention is an attaching spring clip, shown generally at 28 in Figures 3A and 3B. Clip 28 is used to releasably attach heat sink 20 to a selected surface mounting member 30 secured to or part of the equipment chassis/housing shown generally at 45 in Figure 4. Spring clip 28 is made from a strong, flexible material, typically spring steel. The respective side portions 38, 39 of clip 28 curve downwardly and then back toward the center portion 40 of the clip, forming a partial circle, while a center portion 40 dips inwardly, forming

a shallow or concave trough. Further, the corners 41a, 43a of each end portion 41, 43 flare (bend) downwards at an angle relative to the remainder of the end portions, permitting convenient insertion of the heat sink between the end portions of the clip and the surface of the mounting member. In the embodiment shown in Figures 3A and 3B, spring clip 28 is 20 mm long, with 13 mm between the respective free ends thereof. These dimensions can, of course, be varied. The configuration of spring clip 28 can also be varied to some extent. Some variations are shown in Figures 6A-6E.

Spring clip 28 is mounted through surface mounting member 30 (Figure 1). In the embodiment shown, surface mounting member 30 is securely attached to, i.e. not easily removed from, equipment chassis 45. In Figure 4, as one example, mounting member 30 is a thin metal sheet which fits into a slot in the electronic equipment unit chassis 45, or it could be an inner surface of the electronic equipment unit chassis or an actual part of the chassis, such as a center wall thereof.

Mounting member 30 is made from a thermally conductive material, typically aluminum, and if not part of the equipment unit chassis per se, is secured to the housing by welding, a threaded fastener, a mechanical clamp or by an interference fit.

Referring to Figure 1, two narrow rectangular openings 46, 48 are provided through the mounting member. The openings 46, 48 are configured to permit passage of the end portions 41, 43 of the spring clip, but are separated by more than the distance between the free ends thereof. Spring clip 28 is loosely mounted to the mounting member 30 by passing one clip end, e.g. end portion 41, through one opening, e.g. opening 46, in the mounting member, and then pressing the clip toward the mounting member in the center portion thereof. As pressure is applied, spring clip 28 will bend, moving the ends of the clip apart until the other clip end portion 43 passes through the other opening 48 in the mounting member 30. When the pressure is released, clip 28 returns to its normal configuration, held loosely in the two openings 46, 48, so that it can move, but cannot become disengaged from the mounting member.

The arrangement between the engaged spring clip 28 and the mounting member is such that the clip 28 can move in all three axes but will not come out of the openings 46, 48 of the mounting member; it is captive but floating relative to the mounting member. Figure 1 shows the clip in engagement with the mounting member.

When the mounting member is operatively positioned in the electronic equipment chassis 45 (if the mounting member is in fact separate from the equipment chassis), the printed circuit assembly 10 is then moved into juxtaposition with the mounting member, such that disc 21 of the heat sink 20 moves between the clip end portions 41, 43 of the spring clip and adjacent surface 44 of the mounting member. The end corners of the spring clip are configured in such a way as to conveniently allow disc 21 of heat sink 20 to slide between the clip end portions 41, 43 and the surface 44.

As the heat sink thus engages the ends of the spring clip, the spring clip will bend and exert a force on the heat sink, pulling the heat sink against surface 44 of the mounting member, resulting in solid thermal contact between the heat sink on the printed circuit assembly and the mounting member. This results in a low thermal resistance connection between the heat sink and the mounting member.

The physical arrangement between the printed circuit assembly 10 with attached heat sink 20 and spring clip 28 held in mounting member 30 is shown in Figures 4 and 5A, 5B. Figure 4 shows an example of an electronic equipment unit 32, with a mounting member 30 fully engaged with the electronic equipment unit chassis 45, and a partially inserted printed circuit assembly 10 with attached heat sink 20. As the printed circuit assembly is moved fully into the electronic equipment unit 32, the heat sink engages the ends of the clip which extend through the mounting member. The relative position of the mounting member and the printed circuit assembly within the equipment ensure the desired engagement between the heat sink 20 and the spring clip 28. Figures 5A and 5B show elevational and cross-sectional views of the full engagement of the heat sink on the

printed circuit assembly and the spring clip which extends through the mounting member.

The mounting member 30, as indicated above, is solidly mounted to the equipment unit chassis 45, and the heat sink 20 is solidly mounted to the integrated circuit 14, with both connections having low thermal resistance. The total thermal resistance, from the IC itself on the printed circuit assembly to the equipment unit chassis, thus is minimized. As indicated above, the mounting member 30 can either be a separate element, as shown in the various figures, or it can be a part of the actual equipment chassis itself.

In operation, heat flows from the integrated circuit itself, which is consuming power, to the heat sink, to the mounting member, to the equipment chassis and then to the ambient air surrounding the equipment. The semiconductor junctions are thus prevented from heating excessively.

As discussed above, the mounting member 30 containing the spring clip can be attached at different locations to the equipment chassis to provide the desired thermal connection therewith. Attaching the mounting member at different locations to the chassis permits this cooling arrangement to be used at various locations in the equipment chassis. Further, the mounting member can be either a separate element from the chassis, or can be a part of the chassis itself.

In the embodiment shown, mounting member 30 is manufactured with a treatment of surface 44 which allows the heat sink to slide easily over surface 44 until it mates with the spring clip 28, while still producing a relatively large force between the heat sink and the mounting member after mating of the elements occurs.

The surface treatment is embossing a selected area around the protruding portion of the clip. The embossed area is approximately 0.8 mm higher than the remainder of the surface member, so that the embossed area assists in minimizing the distance that the central portion of the spring clip is above the opposing surface 50 of the mounting member, i.e. a "low profile" spring clip. This helps to avoid interference of the

bowed portion of the spring clip with adjacent features, such as other components of the printed circuit assembly.

Further, the embossed area of surface 44 can be treated with a lubricant, such as oil or thermal grease that will decrease thermal resistance and also decrease sliding friction, resulting in easier insertion of a circuit card assembly.

Accordingly, a system has been disclosed which provides a reliable thermal connection between a printed circuit assembly and ultimately the equipment, resulting in heat from the semiconductor junctions being removed therefrom to the ambient air outside the equipment. The system permits the breaking and the reestablishing of a thermal connection between an IC and the equipment chassis without detrimentally affecting the removal of heat from the IC junction.

Although a preferred embodiment of the invention has been disclosed for purposes of illustration, it should be understood that various changes, substitutions and modifications may be incorporated in such embodiment without departing from the spirit of the invention which is defined by the claims which follow.

What is claimed is: